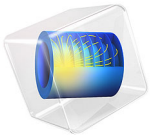


Steam Reformer Geometry

Introduction

Named selections in COMSOL Multiphysics collect geometric entities so that these can easily be reused for any number of model definitions, and are therefore a useful tool for an efficient simulation setup.

The types of selections that are available include the explicit selection features where you can collect individual geometry objects or geometric entities, for example boundaries and edges. You can also create coordinate-based selections to combine entities enclosed by the part of the geometry defined by the volume, area or interval specified in the selection. You can set up both of these selection types either under the Definitions or the Geometry subnodes of a Component node in a model.

In addition to the selection features that you can add to the model tree, you can configure the features under a Geometry node (that is, the operations in the geometry sequence) to automatically create selections that contain the resulting entities from the operation. Geometry operations can also contribute to cumulative selections that are useful for more sophisticated designs where entirely different definitions of selections may be needed in different branches, which are controlled by If nodes of the geometry sequence.

Other selection types include the selection of adjacent geometric entities and Boolean selections, including union, intersection, difference, and complement selections, which can be used to combine any previously defined selections and give you even more flexibility when setting up a model.

Selections that are added under the Definitions node can include geometric entities that exist on the finalized geometry on which you define the physics settings. You can use these selections, for example, for material and physics assignments, when creating a mesh or when creating views for results plots. Selections that you create inside the geometry sequence can, in addition, be used as input to feature nodes downstream of the selection in the sequence. Selections in the geometry sequence thus contain the objects and entities that exist at the current build state of the geometry. They are of help when you want to create robust, parameterized designs in cases when changing parameter values result in significant changes of the topology.

In this tutorial you will leverage selections for creating the parametric geometry for the analysis of a steam reformer and set up the selections needed for the physics definitions. The multiphysics analysis of the steam reformer is described in the model *Steam Reformer* found in the Chemical Reaction Engineering Module Application Library.

Model Definition

The geometry that represents a quarter of the steam reformer is shown in Figure 1. For each of the regions shown in the figure we will set up selections that contain the corresponding domains in the geometry. We will also define boundary selections for the inlets and outlets, symmetry boundaries, and the interfaces between the domains.

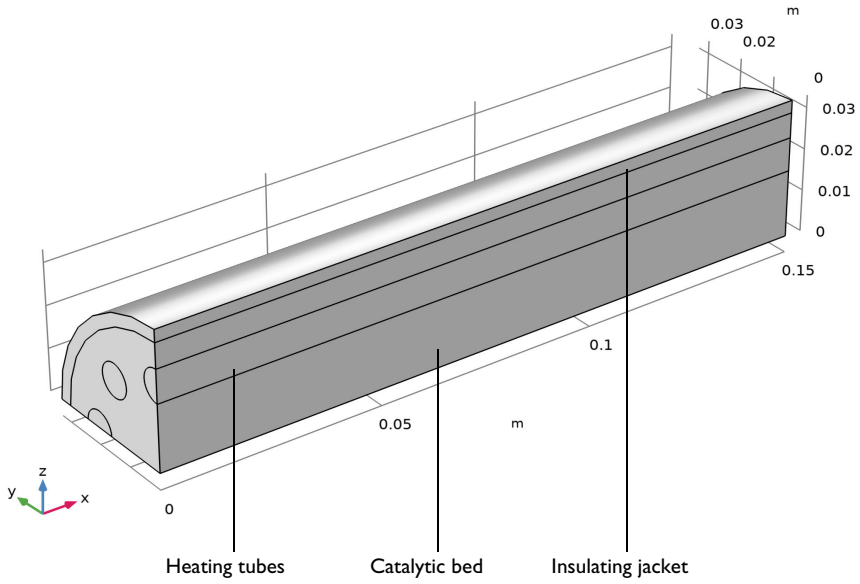


Figure 1: Steam Reformer, quarter.

To create the geometry, you start by drawing the cross section on a work plane; see Figure 2, where the number of heating tubes is parameterized.

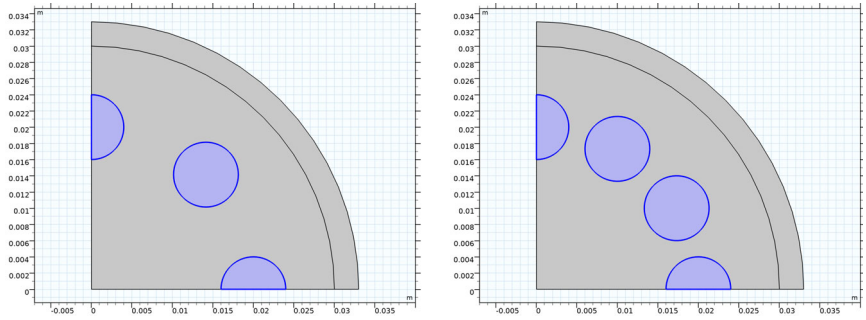


Figure 2: The cross section of the steam reformer. The number of heating tubes can be changed by a parameter.

After following this tutorial, you will be able to:

- Create Resulting object selections
- Use selections as input for geometry features
- Create Adjacent selections
- Combine selections with Boolean selections, such as
  - Intersection Selection
  - Difference Selection
- Set up a parameterized geometry where selections are automatically maintained when the topology is changing

This example describes only the process of creating the geometry sequence. For the physics setup, follow the instructions for the model *Steam Reformer* in the Chemical Reaction Engineering Module Application Library.

Application Library path: `COMSOL_Multiphysics/Geometry_Tutorials/steam_reformer_geometry`

Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click **Blank Model**.

GLOBAL DEFINITIONS

Parameters 1

1 In the **Model Builder** window, under **Global Definitions** click **Parameters 1**.

2 In the **Settings** window for **Parameters**, locate the **Parameters** section.

3 In the table, enter the following settings:

Name	Expression	Value	Description
L	0.15[m]	0.15 m	Bed length
jr	33[mm]	0.033 m	Jacket radius
br	30[mm]	0.03 m	Bed radius
tr	4[mm]	0.004 m	Tube radius
nt	8	8	Number of tubes, must be a multiple of four
pt	20[mm]	0.02 m	Radius of the centers of tubes

ADD COMPONENT

In the **Home** toolbar, click **Add Component** and choose **3D**.

GEOMETRY 1

Start with drawing the cross section of the geometry on a **Work Plane**.

Work Plane 1 (wp1)

1 In the **Geometry** toolbar, click **Work Plane**.

2 In the **Settings** window for **Work Plane**, locate the **Plane Definition** section.

3 From the **Plane** list, choose **yz-plane**.

4 Click **Show Work Plane**.

Work Plane 1 (wp1)>Circle 1 (c1)

1 In the **Work Plane** toolbar, click **Circle**.

2 In the **Settings** window for **Circle**, locate the **Size and Shape** section.

3 In the **Radius** text field, type `jr`.

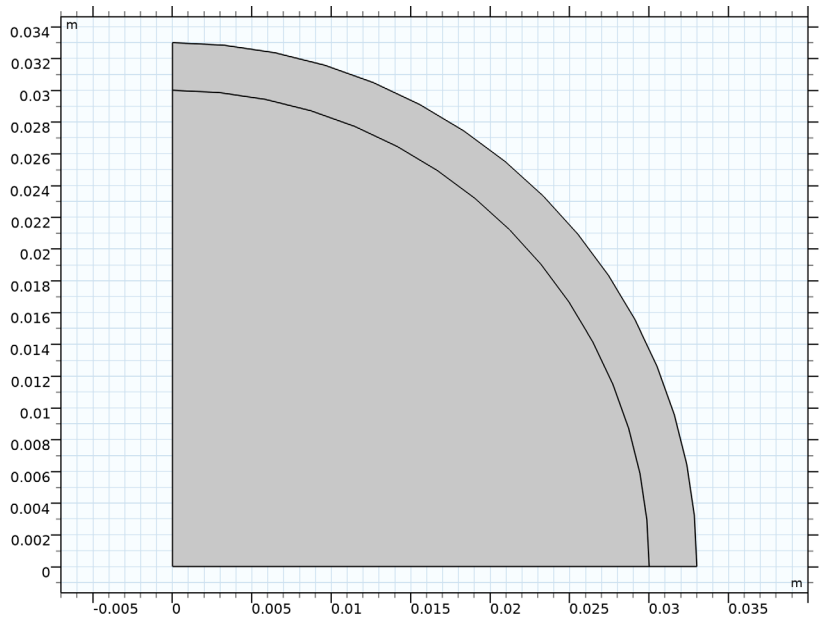
4 In the **Sector angle** text field, type 90.

5 Click to expand the **Layers** section. In the table, enter the following settings:

Layer name	Thickness (m)
Layer 1	jr-br

6 Click **Build Selected**.

7 Click the **Zoom Extents** button in the **Graphics** toolbar.



Tubes Outlet

1 In the **Work Plane** toolbar, click **Circle**.

2 In the **Settings** window for **Circle**, type `Tubes Outlet` in the **Label** text field.

3 Locate the **Size and Shape** section. In the **Radius** text field, type `tr`.

4 Locate the **Position** section. In the **yw** text field, type `pt`.

5 Locate the **Selections of Resulting Entities** section. Select the **Resulting objects selection** check box.

6 From the **Show in 3D** list, choose **All levels**.

With this option selected a selection with a selection with the name of the node will be available for subsequent geometry operations in the geometry sequence of the work plane and the 3D geometry sequence.

Now use the Rotate operation to create a circular array of the heating tubes.

Work Plane 1 (wp1)>Rotate 1 (rot1)

1 In the **Work Plane** toolbar, click **Transforms** and choose **Rotate**.

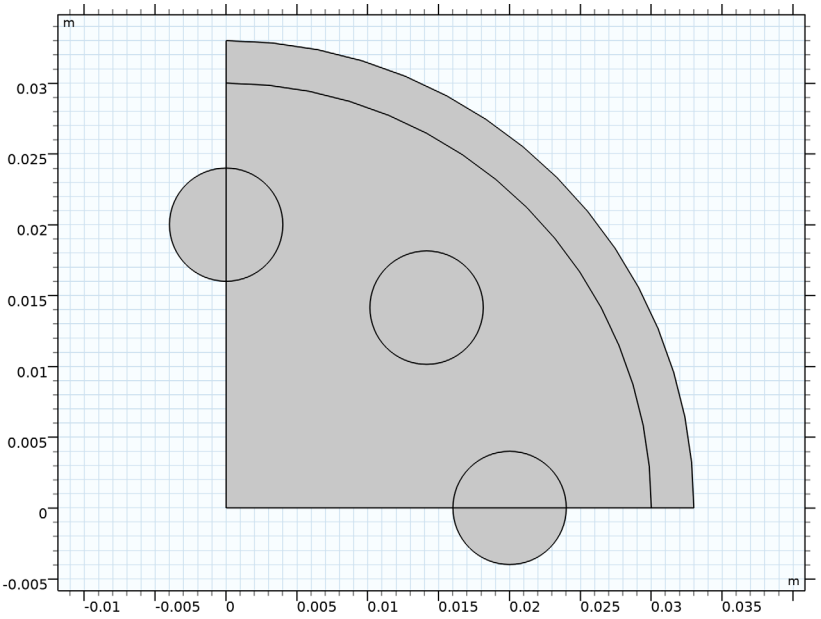
2 In the **Settings** window for **Rotate**, locate the **Input** section.

3 From the **Input objects** list, choose **Tubes Outlet**.

The range operator makes it easy to define the rotation. In this case the angle between the heating tubes is `360/nt [deg]` and we need to generate one quarter of the geometry.

4 Locate the **Rotation** section. In the **Angle** text field, type `-range(0,360/nt,360/4)`.

5 Click **Build Selected**.



Work Plane 1 (wp1)>Union 1 (uni1)

1 In the **Work Plane** toolbar, click **Booleans and Partitions** and choose **Union**.

2 In the **Settings** window for **Union**, locate the **Union** section.

3 From the **Input objects** list, choose **Tubes Outlet**.

4 Click **Build Selected**.

The Compose Boolean operation provides an easy way of combining the geometry objects created so far. An alternative way to get the same results is to use the Union and Intersection Boolean operations.

Work Plane 1 (wp1)>Compose 1 (co1)

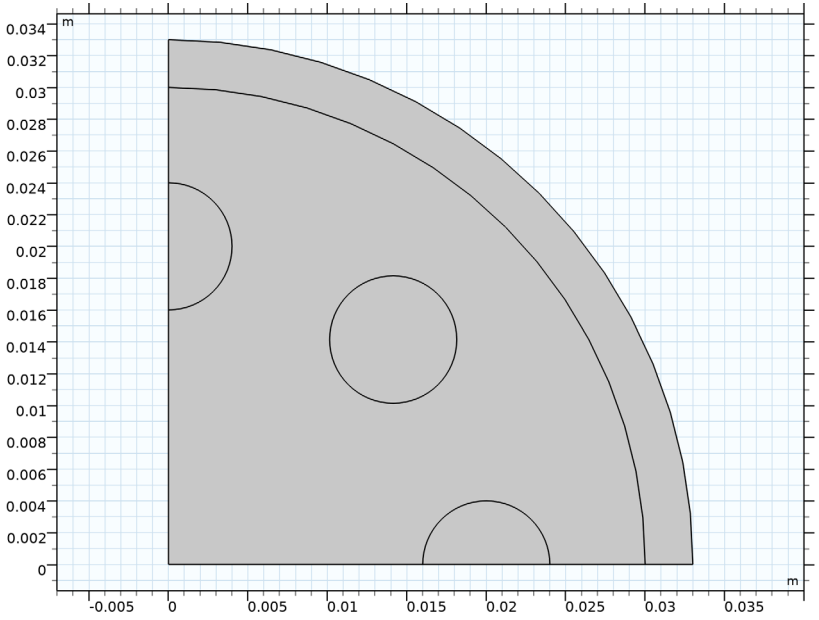
1 In the **Work Plane** toolbar, click **Booleans and Partitions** and choose **Compose**.

2 Click the **Select All** button in the **Graphics** toolbar.

3 In the **Settings** window for **Compose**, locate the **Compose** section.

4 In the **Set formula** text field, type `c1+c1*uni1`.

5 Click **Build Selected**.



Next, define the selection for the bed inlet that is the face (domain in the work plane) that is adjacent to the heating tubes.

Bed Inlet

1 In the **Work Plane** toolbar, click **Selections** and choose **Adjacent Selection**.

2 In the **Settings** window for **Adjacent Selection**, locate the **Input Entities** section.

3 Click **Add**.

4 In the **Add** dialog box, select **Tubes Outlet** in the **Input selections** list.

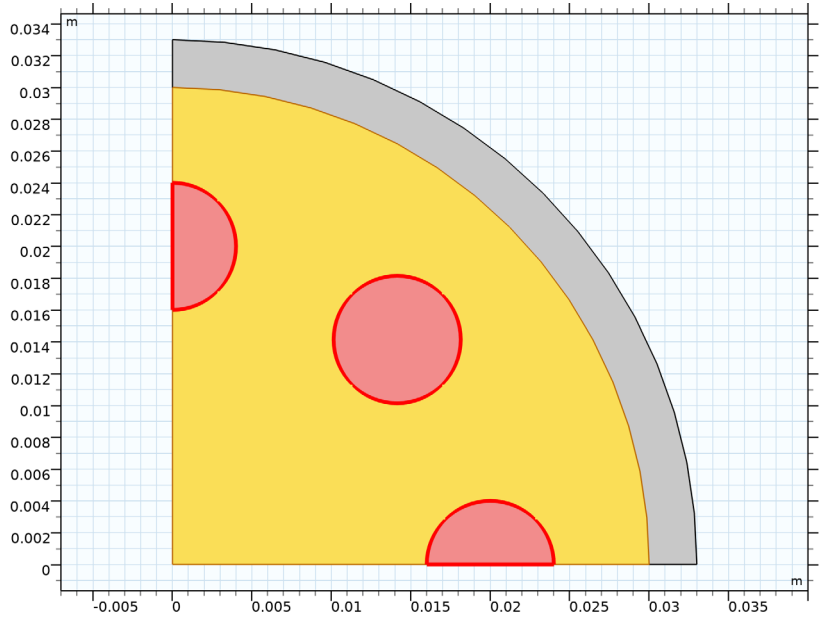
5 Click **OK**.

6 In the **Settings** window for **Adjacent Selection**, locate the **Output Entities** section.

7 From the **Geometric entity level** list, choose **Adjacent domains**.

8 In the **Label** text field, type `Bed Inlet`.

9 Click **Build Selected**.



Work Plane 1 (wp1)

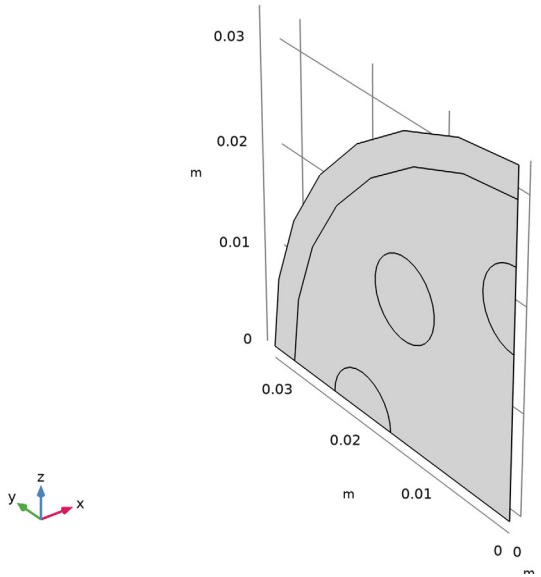
1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** click **Work Plane 1 (wp1)**.

2 In the **Settings** window for **Work Plane**, locate the **Unite Objects** section.

3 Clear the **Unite objects** check box.

4 Locate the **Selections of Resulting Entities** section. Find the **Selections from plane geometry** subsection. Select the **Show in physics** check box, to make the selections from the work plane available for the physics setup.

5 Click **Build Selected**.



Extrude the faces from the work plane. The label of the feature node becomes the name of the output selection when you use the **Resulting object selections** option for the operation.

Jacket

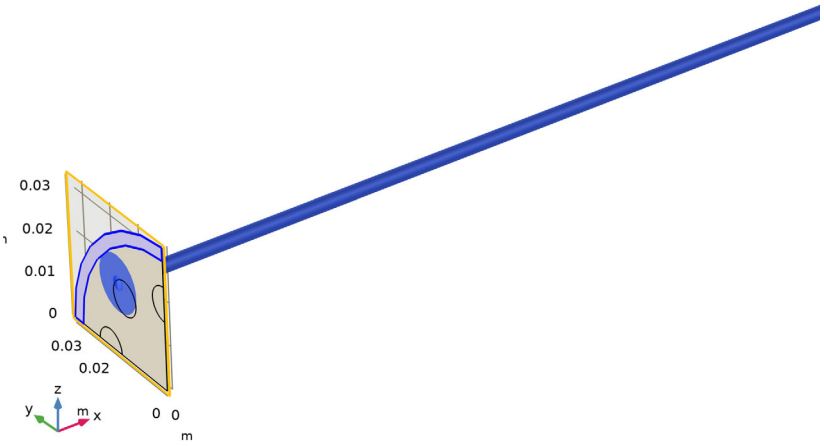
1 In the **Geometry** toolbar, click **Extrude**.

2 In the **Settings** window for **Extrude**, type `Jacket` in the **Label** text field.

3 Locate the **General** section. From the **Extrude from** list, choose **Faces**.

4 On the object **wp1**, select Boundary 3 only.

5 From the **Input object handling** list, choose **Keep**.



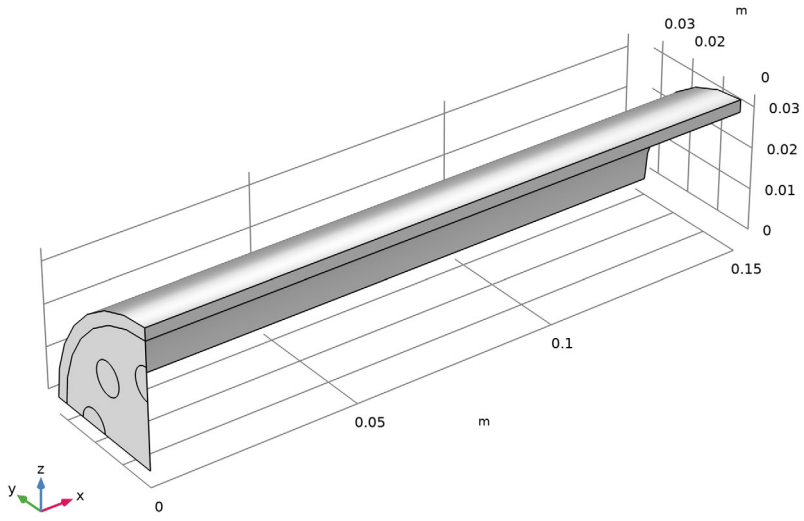
6 Locate the **Distances** section. In the table, enter the following settings:

Distances (m)
L

7 Locate the **Selections of Resulting Entities** section. Select the **Resulting objects selection** check box.

8 From the **Show in physics** list, choose **All levels**.

9 Click **Build Selected**.



Catalytic Bed

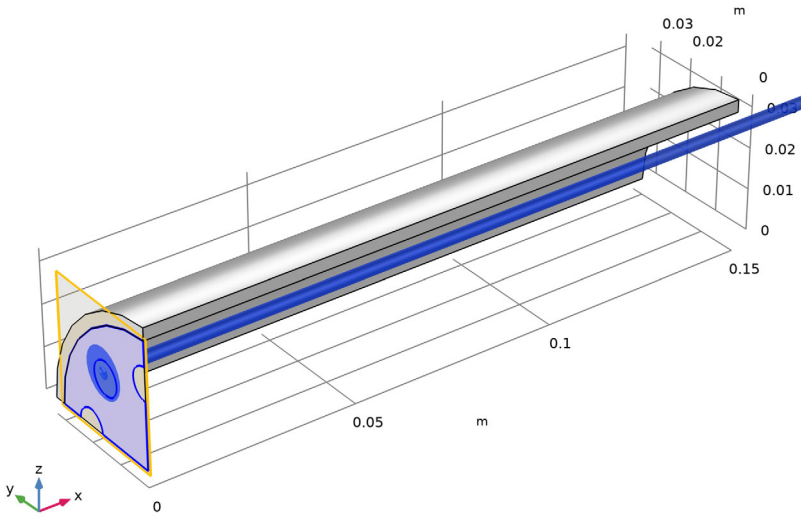
1 In the **Geometry** toolbar, click **Extrude**.

2 In the **Settings** window for **Extrude**, type `Catalytic Bed` in the **Label** text field.

3 Locate the **General** section. From the **Extrude from** list, choose **Faces**.

4 From the **Input faces** list, choose **Bed Inlet (Work Plane 1)**.

5 From the **Input object handling** list, choose **Keep**.



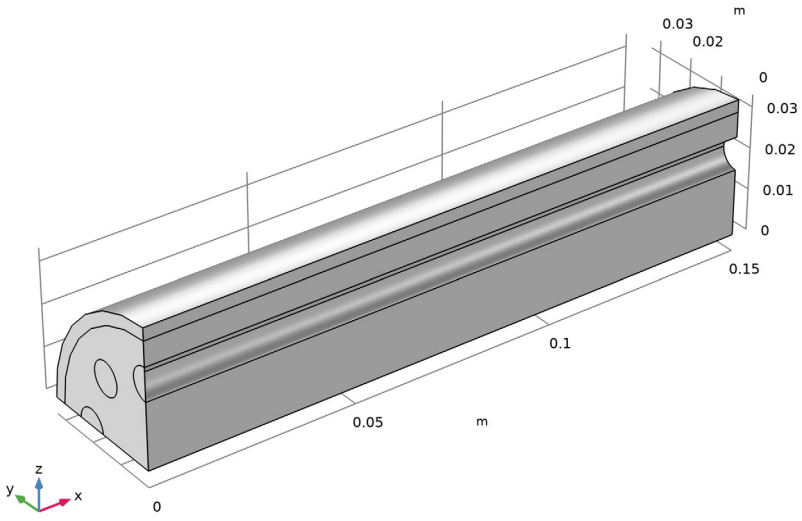
6 Locate the **Distances** section. In the table, enter the following settings:

Distances (m)
L

7 Locate the **Selections of Resulting Entities** section. Select the **Resulting objects selection** check box.

8 From the **Show in physics** list, choose **All levels**.

9 Click **Build Selected**.



Heating Tubes

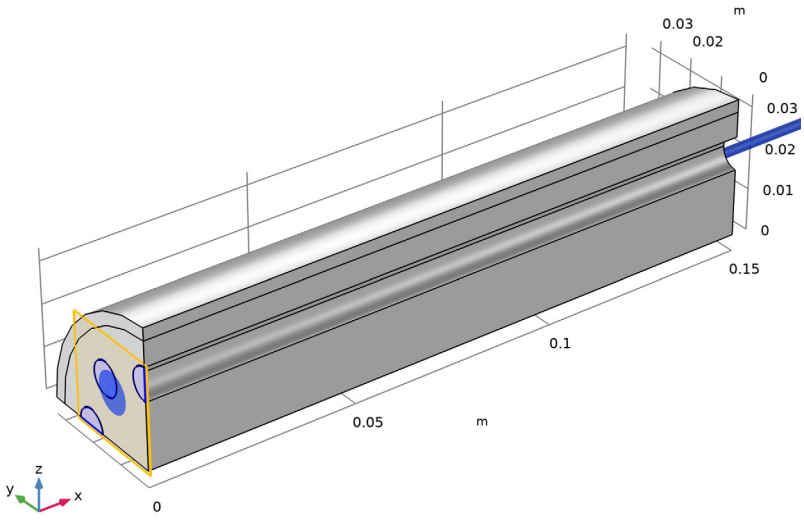
1 In the **Geometry** toolbar, click **Extrude**.

2 In the **Settings** window for **Extrude**, type `Heating Tubes` in the **Label** text field.

3 Locate the **General** section. From the **Extrude from** list, choose **Faces**.

4 From the **Input faces** list, choose **Tubes Outlet (Work Plane 1)**.

5 From the **Input object handling** list, choose **Keep**.



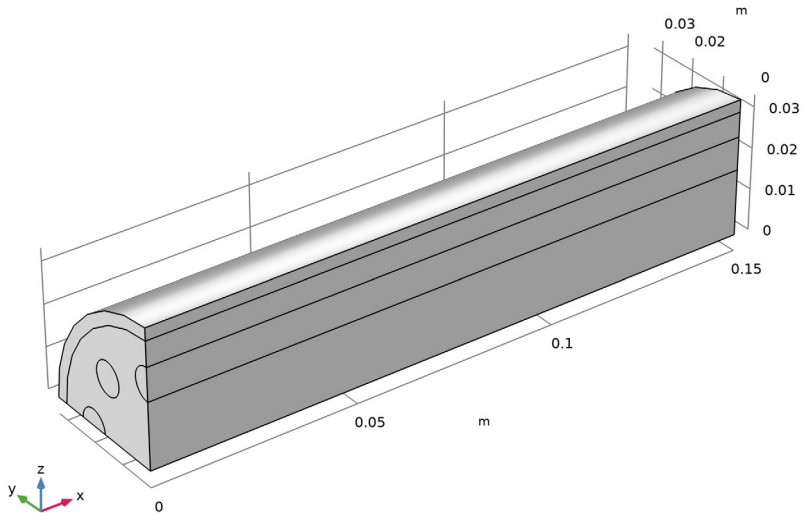
6 Locate the **Distances** section. In the table, enter the following settings:

Distances (m)
L

7 Locate the **Selections of Resulting Entities** section. Select the **Resulting objects selection** check box.

8 From the **Show in physics** list, choose **All levels**.

9 Click **Build Selected**.



Form Union (fin)

1 In the **Model Builder** window, click **Form Union (fin)**.

2 In the **Settings** window for **Form Union/Assembly**, click **Build Selected**.

3 Click the **Wireframe Rendering** button in the **Graphics** toolbar, to get a better overview of the interior entities.

The geometry of the steam reformer is now complete. In the following we will generate the remaining selections for the simulation setup using selection operations. The technique of defining selections as illustrated in this tutorial is especially useful for more complex geometries where manually selecting many geometric entities can be inefficient. This technique can also provide a robust way for creating selections when running geometric parametric sweeps that change the topology, for example when exploring the effect on the results of the number of heating tubes in this geometry.

Bed/Jacket

1 In the **Geometry** toolbar, click **Selections** and choose **Intersection Selection**.

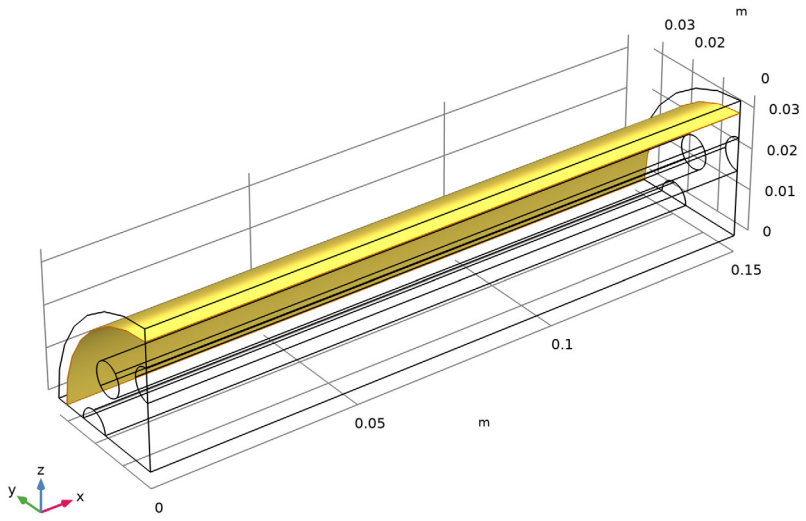
2 In the **Settings** window for **Intersection Selection**, type `Bed/Jacket` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click + **Add**.

5 In the **Add** dialog box, in the **Selections to intersect** list, choose **Jacket** and **Catalytic Bed**.

6 Click **OK**.



Tubes/Bed

1 In the **Geometry** toolbar, click **Selections** and choose **Intersection Selection**.

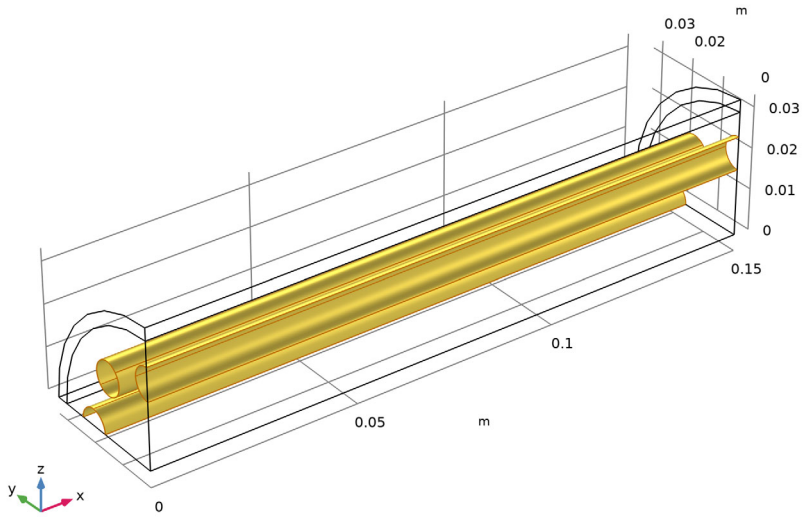
2 In the **Settings** window for **Intersection Selection**, type `Tubes/Bed` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click + **Add**.

5 In the **Add** dialog box, in the **Selections to intersect** list, choose **Catalytic Bed** and **Heating Tubes**.

6 Click **OK**.



Cylinder Selection 1 (cylsel1)

1 In the **Geometry** toolbar, click **Selections** and choose **Cylinder Selection**.

2 In the **Settings** window for **Cylinder Selection**, locate the **Geometric Entity Level** section.

3 From the **Level** list, choose **Boundary**.

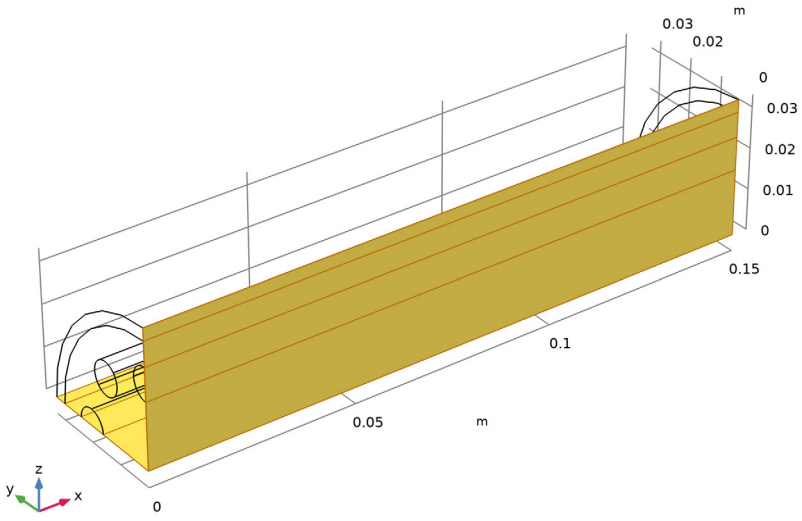
4 Locate the **Size and Shape** section. In the **Outer radius** text field, type `inf`.

5 In the **Start angle** text field, type 180.

6 In the **End angle** text field, type 90.

7 Locate the **Axis** section. From the **Axis type** list, choose **x-axis**.

8 Locate the **Output Entities** section. From the **Include entity if** list, choose **Entity inside cylinder**.



Jacket Symmetry

1 In the **Geometry** toolbar, click **Selections** and choose **Intersection Selection**.

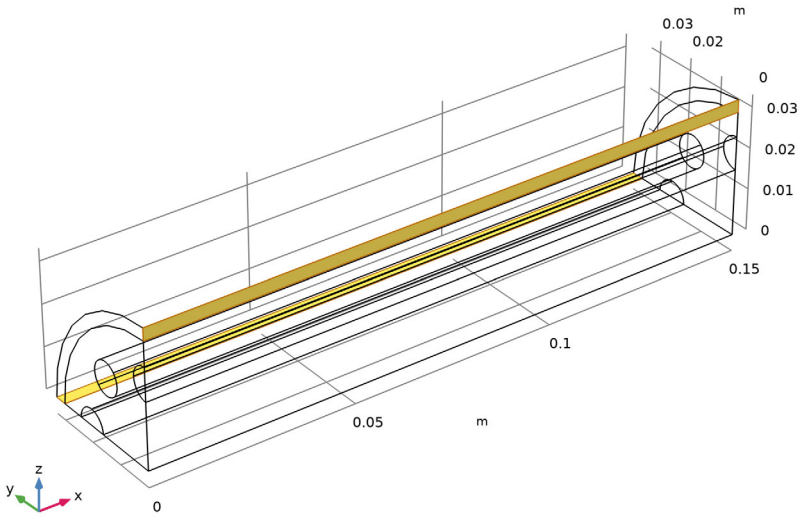
2 In the **Settings** window for **Intersection Selection**, type `Jacket Symmetry` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, in the **Selections to intersect** list, choose **Jacket** and **Cylinder Selection 1**.

6 Click **OK**.



Tubes Symmetry

1 In the **Geometry** toolbar, click **Selections** and choose **Intersection Selection**.

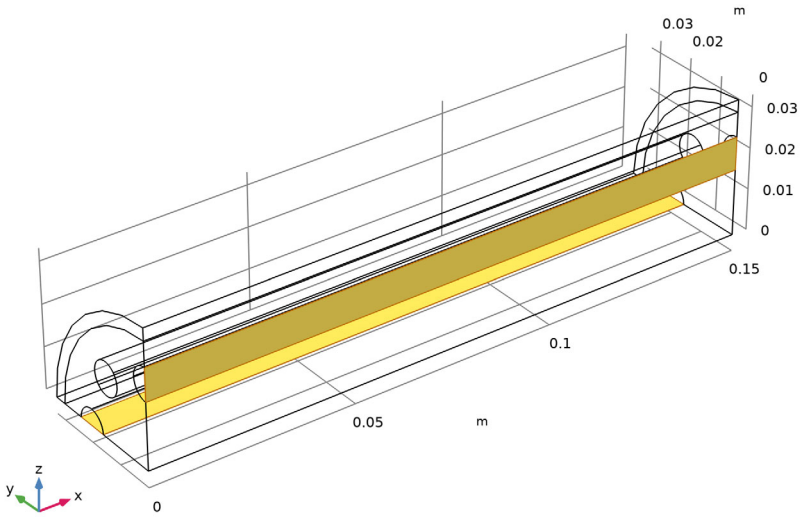
2 In the **Settings** window for **Intersection Selection**, type `Tubes Symmetry` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, in the **Selections to intersect** list, choose **Heating Tubes** and **Cylinder Selection 1**.

6 Click **OK**.



Bed Symmetry

1 In the **Geometry** toolbar, click **Selections** and choose **Intersection Selection**.

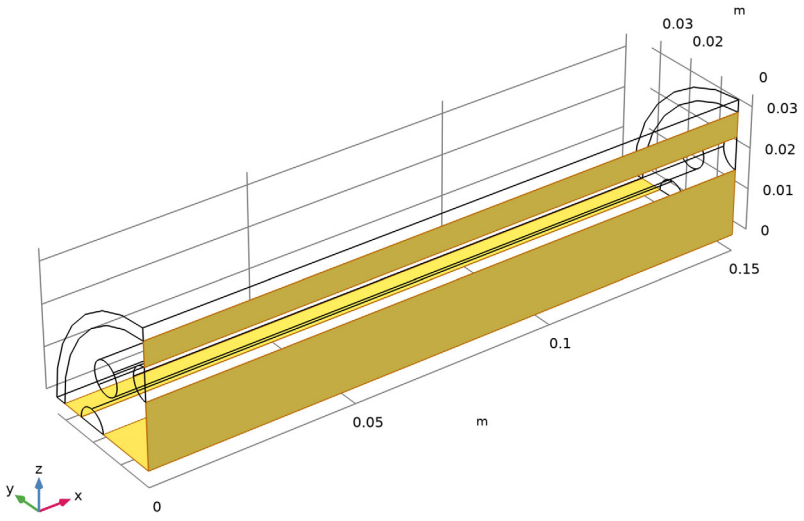
2 In the **Settings** window for **Intersection Selection**, type `Bed Symmetry` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, in the **Selections to intersect** list, choose **Catalytic Bed** and **Cylinder Selection 1**.

6 Click **OK**.



Inlets and Outlets

1 In the **Geometry** toolbar, click **Selections** and choose **Difference Selection**.

2 In the **Settings** window for **Difference Selection**, type `Inlets and Outlets` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, in the **Selections to add** list, choose **Catalytic Bed** and **Heating Tubes**.

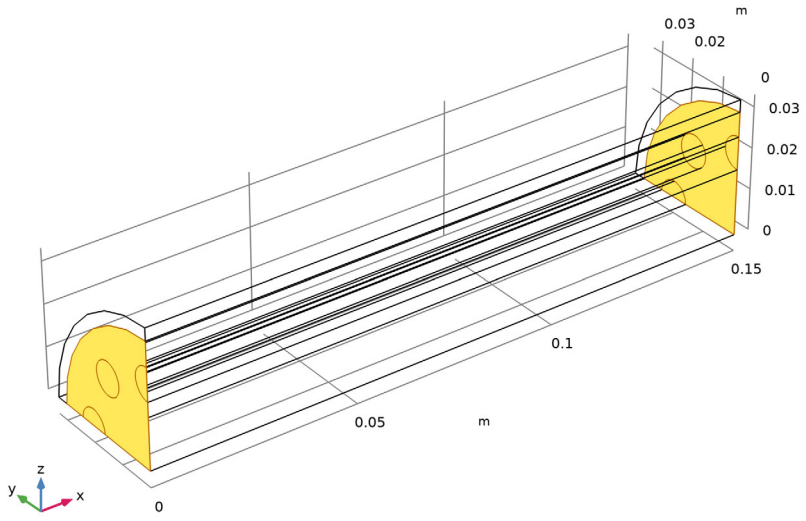
6 Click **OK**.

7 In the **Settings** window for **Difference Selection**, locate the **Input Entities** section.

8 Click **Add**.

9 In the **Add** dialog box, in the **Selections to subtract** list, choose **Bed/Jacket**, **Tubes/Bed**, **Tubes Symmetry**, and **Bed Symmetry**.

10 Click **OK**.



Tubes Inlet

1 In the **Geometry** toolbar, click **Selections** and choose **Difference Selection**.

2 In the **Settings** window for **Difference Selection**, type `Tubes Inlet` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, select **Inlets and Outlets** in the **Selections to add** list.

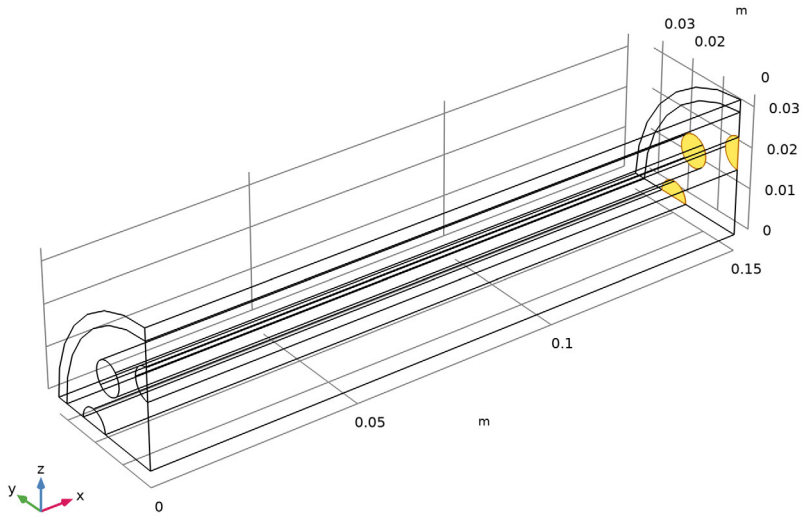
6 Click **OK**.

7 In the **Settings** window for **Difference Selection**, locate the **Input Entities** section.

8 Click **Add**.

9 In the **Add** dialog box, in the **Selections to subtract** list, choose **Tubes Outlet (Work Plane 1)** and **Catalytic Bed**.

10 Click **OK**.



Bed Outlet

1 In the **Geometry** toolbar, click **Selections** and choose **Difference Selection**.

2 In the **Settings** window for **Difference Selection**, type `Bed Outlet` in the **Label** text field.

3 Locate the **Geometric Entity Level** section. From the **Level** list, choose **Boundary**.

4 Locate the **Input Entities** section. Click **Add**.

5 In the **Add** dialog box, select **Inlets and Outlets** in the **Selections to add** list.

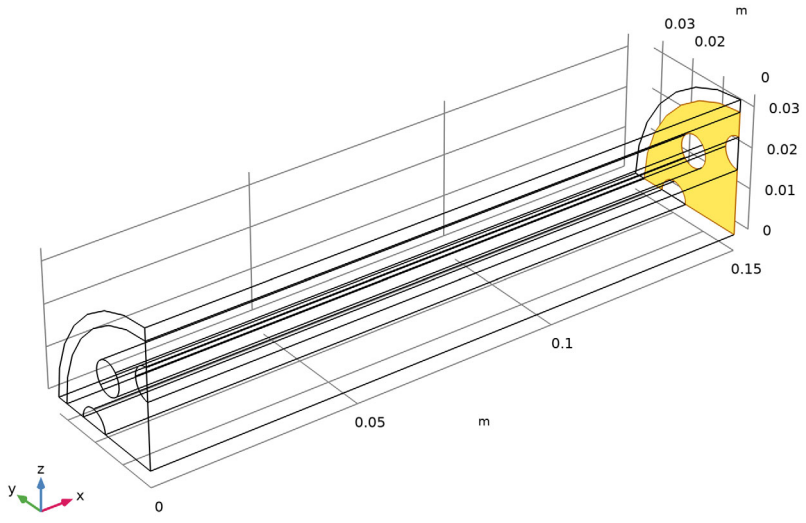
6 Click **OK**.

7 In the **Settings** window for **Difference Selection**, locate the **Input Entities** section.

8 Click **Add**.

9 In the **Add** dialog box, in the **Selections to subtract** list, choose **Bed Inlet (Work Plane 1)** and **Heating Tubes**.

10 Click **OK**.



Jacket/Ambient

1 In the **Geometry** toolbar, click **Selections** and choose **Explicit Selection**.

2 In the **Settings** window for **Explicit Selection**, type `Jacket/Ambient` in the **Label** text field.

3 Locate the **Entities to Select** section. From the **Geometric entity level** list, choose **Boundary**.

4 On the object **fin**, select Boundary 12 only.